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Environmental policy, technology adoption and the size distribution of firms☆

Jessica Coria[a,*], Efthymia Kyriakopoulou[b,c]

[a] Department of Economics, University of Gothenburg, Sweden
[b] Department of Economics, Swedish University of Agricultural Sciences, Sweden
[c] Centre for Research in Economics and Management, University of Luxembourg, Luxembourg

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ABSTRACT

The potential impacts of strict environmental policies on production costs and firms' competitiveness are central to the choice of which policy to implement. However, not all the industries nor all firms within an industry are affected in the same way. In this paper, we investigate the effects of emission taxes, uniform emission standards, and performance standards on the size distribution of firms. Our results indicate that, unlike emission taxes and performance standards, emission standards introduce regulatory asymmetries favoring small firms. On the contrary, emission taxes and performance standards reduce to a lower extent profits of larger firms but they do modify the optimal scale of firms. We also show that when the regulatory asymmetries created by emissions standards are taken into account, the profitability of emissions reducing technologies is higher under emission standards than under market-based instruments.

1. Introduction

Climate change mitigation necessitates the implementation of stringent environmental regulations to control emissions of greenhouse gases. For instance, the successful implementation of the 2030 climate and energy targets in EU requires at least 40% cuts in greenhouse gas emissions (from 1990 levels) and 27% improvement in energy efficiency. The 40% target will only be achieved if EU emissions trading system sectors (ETS) cut emissions by 43% and non-ETS cut emissions by 30% (compared to 2005). The ETS has to be reformed in order to achieve the first target, while achieving the second target requires that Member States implement additional measures to cut emissions and increase the energy efficiency of the non-ETS sectors.

The potential impacts of strict environmental policies on employment, production costs and firms' competitiveness are central to the choice of which policy to implement. Not all the industries will be affected in the same way. For instance, energy-intensive industries that emit larger quantities of greenhouse gases face higher costs from environmental regulations that require firms to pay for the cost of emissions, which can undermine their competitiveness to a greater extent than non energy-intensive industries (see e.g. Aldy and Pizer, 2015; Alexeeva-Talebi et al., 2012). Furthermore, not all the firms in an industry will be affected in the same way. In particular, small firms might be at a disadvantage if there are scale economies in regulatory compliance. In such a case, it might be optimal to exempt or impose lighter regulatory burden on smaller firms, or design regulations that are neutral across firm size to minimize the disproportionate impact of environmental regulatory requirements on small businesses (e.g., Brock and Evans, 1985).

In this paper, we investigate the effects of the choice of policy instruments on the size distribution of firms when compliance with environmental regulation changes the optimal plant size. By this means, we contribute to the understanding of the differential

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* Corresponding author.
E-mail addresses: Jessica.Coria@economics.gu.se (J. Coria), Efthymia.Kyriakopoulou@slu.se (E. Kyriakopoulou).

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effect of regulation across firm size, which is important since societies often have an interest in preserving small businesses because of antitrust or other noneconomic reasons (see e.g., Evans, 1986). Furthermore, understanding the incidence of regulatory costs across firm size allows us to anticipate the interest of certain groups of businesses in supporting alternative regulatory policies. Our paper compares three broadly used environmental policies, namely emission taxes, emission standards, and performance standards. We show that unlike emission taxes and performance standards, emission standards induce regulatory asymmetries favoring small firms. Moreover, unlike previous studies suggesting that market-based instruments create more effective technology adoption incentives than conventional regulatory standards, our results indicate that when the regulatory asymmetries created by emissions standards are taken into account, the profitability of emission saving biased technological change is higher under emission standards than under market-based instruments.

The size distribution of firms has been extensively studied in the industrial organization literature. Most of the literature deals with the distributional properties of firm size (see, e.g., Cabral and Mata, 2003; Angelini and Generale, 2008). However, more recent research has integrated the size distribution of firms into standard economic theory. Attempts to explain the size dynamics have investigated the effects of bad productivity shocks (Hopenhayn, 1992; Ericson and Pakes, 1995), learning (Jovanovic, 1982), inefficiencies in financial markets (Clementi and Hopenhayn, 2006), the exogenous distribution of managerial ability in the population (Lucas, 1978; Garicano and Rossi-Hansberg, 2004), and the efficient accumulation and allocation of factors of production (Rossi-Hansberg and Wright, 2007).

In the environmental economics literature, the effects of alternative environmental policies on market structure have also been investigated (see Millimet et al., 2009 for a survey of theoretical and empirical studies on the economic effects of environmental regulations on market structure). A common finding of this literature is that in competitive markets, emission taxes and (auctioned) emissions trading schemes induce efficient entry of firms in the long run, whereas subsidies on abatement and uniform emission standard policies would distort the entry-exit conditions and induce excessive entry (see e.g., Spulber, 1985; Katsoulacos and Xepapadeas, 1996; Kohn, 1997). Such result might, however, not hold in the case of non-competitive markets (see e.g., Shaffer, 1995). Moreover, the effects on firms' output are unclear and depend on the elasticity of the demand function for the final product (see e.g., Conrad and Wang, 1993; Kohn, 1997). Some studies have also analyzed the effects of certain environmental regulations on industry dynamics. For instance, Konishi and Tarui (2015) and Dardati (2016) investigate the effects of different allocation rules of non-auctioned emission trading schemes on the size distribution of firms, and closing of plants and new entrants, respectively, finding that if permits are not distributed in a manner that disproportionally favors dirtier firms, the distribution of firms after the implementation of the policy has cleaner and more-productive plants.

Our study is, however, closer to earlier studies which have identified two counteracting effects through which environmental policies affect the distribution of size. First, the studies by Pashigian (1984), Dean et al. (2000), and Sengupta (2010) indicate that due to economies of scale, environmental regulation modifies the optimal scale of firms and puts small firms at a unit cost disadvantage. Second, Becker et al. (2013) argue that there are statutory and/or enforcement asymmetries that favor smaller establishments. Hence, the final incidence of environmental regulations depends on whether these regulatory asymmetries outweigh any scale economies in regulatory compliance.

Our study shows that the relative magnitude of these two effects is dependent on the type of environmental policies in place. Under emission taxes and performance standards, the intensity of emissions is determined by the stringency of the regulation and it is the same across firms. In contrast, under emission standards, the regulatory goal is expressed as an absolute emission limit, which favors smaller firms as the limit might not bind their emissions. Our results indicate that emission taxes and performance standards do not introduce regulatory asymmetries, but do modify the optimal scale of the firms. Moreover, the existence of economies of scale implies that these policies reduce to a lower extent profits for larger firms than for smaller firms. In contrast, under emission standards the incidence of the regulatory costs across firm size depends on the two counteracting effects described above, but the final effect is that emission standards reduce the profits of large firms to a larger extent. Moreover, our study shows that when the regulatory asymmetries created by emission standards are taken into account, the profitability of abatement technologies is higher under emission standards than under market-based instruments since the most productive firms (which are likely to invest in new technologies), are more constrained under emission standards. To the best of our knowledge, such a result is new in the literature, and finds some empirical support in the studies by Klemetsen et al. (2016) and Bye and Klemetsen (2018), which find that emission standards induce costs that involve a limit on production activity for the firms, providing strong and persistent incentives for innovation and adoption of new technologies.

To study the effects of the choice of policy instruments on the size distribution of firms, we follow the seminal model by Lucas (1978), where the underlying size distribution of firms in the industry is the result of the existence of a productive factor of heterogenous productivity. In Lucas' model, such a factor is the managerial technology, while in ours it is the energy efficiency of firms.[1] In such a setting, we introduce different environmental policies and analyze the resulting size distributions, as well as the variations in size distribution that arise as a result of investments that reduce the cost of compliance with environmental regulations.

The paper is organized in six sections. The next section presents the model and the underlying size distribution of firms in the absence of environmental policies. The third section analyzes the incidence of regulatory costs across size and how the choice of a policy instrument modifies the size distribution of firms. The fourth section analyzes the effects of the choice of policy instruments on the share of the polluting input and technological choice. The fifth section presents some numerical simulations and analyzes welfare implications. The final section concludes.

2. The model

We assume a perfectly competitive stationary industry consisting of a continuum of risk-neutral single-plant polluting firms of mass 1. Firms produce a homogeneous good using two inputs: energy (e) and labor (l). Moreover, each unit of energy e used as an input generates γ units of emissions ξ, i.e., $\xi_i = \gamma e_i$. Firms differ in terms of the parameter ϕ, which reflects energy efficiency and is assumed to be uniformly distributed on the interval $\left[\underline{\phi}, \bar{\phi}\right]$.

[1] Our model also resembles that of Melitz (2003), who derives a simple model of industry equilibrium in an open economy with heterogeneous firms. Firms differ in terms of their marginal productivity of labor (the only factor of production). The productivity of each firm is randomly drawn from some distribution, but unlike our model, firms do not know their productivity prior to starting production. One of the predictions of the Melitz model is that opening up to trade will increase aggregate productivity.